



U.S. Department  
of Transportation

**Federal Aviation  
Administration**

# Memorandum

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Subject: **ACTION:** Final Policy Statement; Propeller Testing  $V_d$  Versus  
 $V_{NE}$ ; PS-ACE100-2002-008

Date:

From: Manager, Regulations and Policy Branch  
Small Airplane Directorate, ACE-111

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## SUMMARY

The installation of a different propeller model, whether by supplemental, amended, or new type certification, is a significant design change, as defined in Order 8100.5, chapter 1, paragraph 103, subparagraph j, section 2f:

*The design changes the engine configuration from reciprocating to turbo propeller or turbojet powered or changes from one engine or propeller model to a completely different engine or propeller model (does not include dash number changes).*

The Aircraft Certification Office (ACO) is expected to notify the directorate of such projects promptly and forward certification project notifications and associated certification plans as soon as practical after project application. The ACO is expected to identify the technological areas of concern identified in this policy statement, as well as any additional concerns, and develop a G-1 issue paper to establish the certification basis.

The applicant must address 14 CFR part 23, § 23.33, § 23.251 and § 23.629. The applicant should identify the effects of the propeller installation with respect to the airplane's vibration and flutter responses. This policy statement describes two methods of compliance with § 23.251 and § 23.629 where flight testing to  $V_D$  may not be required.

## POLICY

Part 23, § 23.33 requires flight testing up to the aircraft's  $V_{NE}$ . Compliance with § 23.33 is typically shown with a flight test demonstrating safe operation under normal operating conditions. The intent of § 23.33 is to ensure that propeller overspeeds do not occur within the normal flight envelope.

Part 23, § 23.251 requires flight testing up to the aircraft's  $V_D$ . Compliance with § 23.251 is typically shown with a flight test demonstrating that all design analysis and margins related to airframe vibration and buffeting, including those established for the propeller/engine/airframe, are adequate to provide a safe airplane up to its dive speed, but does not show freedom from flutter within the flight envelope. The intent of § 23.251 is to ensure that the airframe is free of excessive vibration and buffeting within the normal flight envelope.

Part 23, § 23.629 requires flight testing up to the aircraft's  $V_D$ . Compliance with § 23.629 is typically shown with a flight test demonstrating that all design analysis and margins related to airframe flutter modes, including those established for the propeller/engine/airframe, are adequate to provide an airplane free of flutter up to its dive speed. The intent of § 23.629 is to ensure that the airframe is free of flutter within the normal flight envelope.

This policy statement does not change the requirements for compliance with § 23.251 and § 23.629 during initial aircraft certification, but rather when installing a different propeller model on an already type certificated aircraft, whether by supplemental or amended type certification. To demonstrate compliance with § 23.251 and § 23.629 for the installation of propeller via ATC or STC on previously certified aircraft, the applicant has three choices:

1. Demonstrate by analysis, using methodology and data acceptable to the FAA, that the propeller installation does not adversely affect the flutter characteristics identified by § 23.629. If there are no significant changes in the vibration characteristics of the aircraft, then the flight testing to  $V_{NE}$  required by § 23.33 will be considered sufficient to meet the requirements of § 23.251 and § 23.629.

- OR -

2. Conduct before and after propeller installation ground vibration tests (GVT) to determine the aircraft's vibration characteristics. Determine by the comparison of the modal parameters (frequencies, mode shapes and node points) obtained by these two tests whether the vibration characteristics of the aircraft are significantly altered by this installation. If there are no significant changes in the vibration characteristics of the aircraft, then the flight testing to  $V_{NE}$  required by § 23.33 will be considered sufficient to meet the requirements of § 23.251 and § 23.629.

- OR -

3. Conduct flight testing to  $V_D$  per AC23-8A and AC23-629-1A to demonstrate compliance with the requirements of § 23.251 and § 23.629, in addition to the flight testing to  $V_{NE}$  required by § 23.33.

## BACKGROUND

The Small Airplane Certification Directorate has recently received a large number of supplemental type certification applications for replacement propeller installations on single engine airplanes with a reciprocating engine. The propellers are issued a type certificate (TC) under 14 CFR part 21, import propellers are issued a TC in accordance with § 21.29 (accepted under the bilateral agreement with the exporting country). The applicant questioned whether the airplanes modified with these propellers should be required to fly to dive speed under part 23, § 23.251 as part of the supplemental type certificate (STC) program in addition to showing compliance to § 23.33 for propeller overspeed.

In general, § 23.251 and § 23.629 do not explicitly call out the propulsion system configuration, except in the case of § 23.629 for turbo propeller airplanes, as a component in their requirements. The propulsion system can have an influence on the vibration and flutter characteristics of an airplane. In most general aviation aircraft, the airframes natural frequencies are of a lower magnitude than the frequencies excited by the propeller slipstream, which could act as forcing function. In the case of a propeller with an imbalance in one blade of the propeller, the vibration caused by this imbalance could negatively impact the flutter margin.

Propeller overspeeds can occur during high-speed flight, such as the dive test. Overspeeding refers to a condition where the engine or propeller revolutions per minute (RPM) limit is exceeded because the airplane is going fast enough to unload the propeller and allow the engine to proceed beyond the engine speed limits.

Part 23, § 23.33, Amendment 23-50 states:

- (a) General. The propeller speed and pitch must be limited to values that will assure safe operation under normal operating conditions.*
- (b) Propellers not controllable in flight. For each propeller whose pitch cannot be controlled in flight--*
  - (1) During takeoff and initial climb at the all engine(s) operating climb speed specified in Sec. 23.65, the propeller must limit the engine r.p.m., at full throttle or at maximum allowable takeoff manifold pressure, to a speed not greater than the maximum allowable takeoff r.p.m.; and*
  - (2) During a closed throttle glide, at  $V_{NE}$ , the propeller may not cause an engine speed above 110 percent of maximum continuous speed.*
- (c) Controllable pitch propellers without constant speed controls. Each propeller that can be controlled in flight, but that does not have constant speed controls, must have a means to limit the pitch range so that--*
  - (1) The lowest possible pitch allows compliance with paragraph (b)(1) of this section; and*
  - (2) The highest possible pitch allows compliance with paragraph (b)(2) of this section.*
- (d) Controllable pitch propellers with constant speed controls. Each controllable*

*pitch propeller with constant speed controls must have--*

- (1) With the governor in operation, a means at the governor to limit the maximum engine speed to the maximum allowable takeoff r.p.m.; and*
- (2) With the governor inoperative, the propeller blades at the lowest possible pitch, with takeoff power, the airplane stationary, and no wind, either--*
  - (i) A means to limit the maximum engine speed to 103 percent of the maximum allowable takeoff r.p.m., or*
  - (ii) For an engine with an approved overspeed, a means to limit the maximum engine and propeller speed to not more than the maximum approved overspeed.*

Part 23, § 23.251, Amendment 23-45 states:

*There must be no vibration or buffeting severe enough to result in structural damage, and each part of the airplane must be free from excessive vibration, under any appropriate speed and power conditions up to  $V_D/M_D$ . In addition, there must be no buffeting in any normal flight condition severe enough to interfere with the satisfactory control of the airplane or cause excessive fatigue to the flight crew. Stall warning buffeting within these limits is allowable.*

Part 23, § 23.629, Amendment 23-48 states:

- (a) It must be shown by the methods of paragraph (b) and either paragraph (c) or (d) of this section, that the airplane is free from flutter, control reversal, and divergence for any condition of operation within the limit  $V$ - $n$  envelope and at all speeds up to the speed specified for the selected method. In addition--*
  - (1) Adequate tolerances must be established for quantities which affect flutter, including speed, damping, mass balance, and control system stiffness; and*
  - (2) The natural frequencies of main structural components must be determined by vibration tests or other approved methods.*
- (b) Flight flutter tests must be made to show that the airplane is free from flutter, control reversal and divergence and to show that--*
  - (1) Proper and adequate attempts to induce flutter have been made within the speed range up to  $V_D$ ;*
  - (2) The vibratory response of the structure during the test indicates freedom from flutter;*
  - (3) A proper margin of damping exists at  $V_D$ ; and*
  - (4) There is no large and rapid reduction in damping as  $V_D$  is approached.*
- (c) Any rational analysis used to predict freedom from flutter, control reversal and divergence must cover all speeds up to  $1.2 V_D$ .*
- (d) Compliance with the rigidity and mass balance criteria (pages 4-12), in Airframe and Equipment Engineering Report No. 45 (as corrected) "Simplified Flutter Prevention Criteria" (published by the Federal Aviation Administration) may be accomplished to show that the airplane is free from flutter, control reversal, or divergence if--*
  - (1)  $V_D/M_D$  for the airplane is less than 260 knots (EAS) and less than Mach 0.5,*

- (2) The wing and aileron flutter prevention criteria, as represented by the wing torsional stiffness and aileron balance criteria, are limited in use to airplanes without large mass concentrations (such as engines, floats, or fuel tanks in outer wing panels) along the wing span, and*
- (3) The airplane--*
  - (i) Does not have a T-tail or other unconventional tail configurations;*
  - (ii) Does not have unusual mass distributions or other unconventional design features that affect the applicability of the criteria, and*
  - (iii) Has fixed-fin and fixed-stabilizer surfaces.*
- (e) For turbo propeller-powered airplanes, the dynamic evaluation must include--*
  - (1) Whirl mode degree of freedom which takes into account the stability of the plane of rotation of the propeller and significant elastic, inertial, and aerodynamic forces, and*
  - (2) Propeller, engine, engine mount, and airplane structure stiffness and damping variations appropriate to the particular configuration.*
- (f) Freedom from flutter, control reversal and divergence up to  $V_D/M_D$  must be shown as follows:*
  - (1) For airplanes that meet the criteria of paragraphs (d)(1) through (3) of this section, after the failure, malfunction, or disconnection of any single element in any tab control system.*
  - (2) For airplanes other than those described in paragraph (f)(1) of this section, after the failure, malfunction, or disconnection of any single element in the primary flight control system, any tab control system, or any flutter damper.*
- (g) For airplanes showing compliance with the fail-safe criteria of Secs. 23.571 and 23.572, the airplane must be shown by analysis to be free from flutter up to  $V_D/M_D$  after fatigue failure, or obvious partial failure, of a principal structural element.*
- (h) For airplanes showing compliance with the damage tolerance criteria of Sec. 23.573, the airplane must be shown by analysis to be free from flutter up to  $V_D/M_D$  with the extent of damage for which residual strength is demonstrated.*
- (i) For modifications to the type design that could affect the flutter characteristics, compliance with paragraph (a) of this section must be shown, except that analysis based on previously approved data may be used alone to show freedom from flutter, control reversal and divergence, for all speeds up to the speed specified for the selected method.*

## **Effect of Policy**

The general policy stated in this document does not constitute a new regulation or create what the courts refer to as a "binding norm". The office that implements policy should follow this policy when applicable to the specific project. Whenever an applicant's proposed method of compliance is outside this established policy, it must be coordinated with the policy issuing office, e.g., through the issue paper process or equivalent. Similarly, if the implementing office becomes aware of reasons that an applicant's proposal that meets this policy should not be approved, the office must coordinate its response with the policy issuing office.

Applicants should expect that the certificating officials will consider this information when making findings of compliance relevant to new certificate actions. Also, as with all advisory material, this policy statement identifies one means, but not the only means, of compliance.

## **CONCLUSION**

14 CFR part 23, § 23.33, § 23.251, and § 23.629 must be addressed when approving replacement propellers. While flight testing to  $V_D$  may not be required to show compliance, the effects of the propeller installation will have to be quantified with respect to the airplane's vibration and flutter responses.

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for

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